PROJECT SUMMARY

Instructions:
The summary is limited to 250 words. The names and affiliated organizations of all Project Directors/Principal Investigators (PD/PI) should be listed in addition to the title of the project. The summary should be a self-contained, specific description of the activity to be undertaken and should focus on: overall project goal(s) and supporting objectives; plans to accomplish project goal(s); and relevance of the project to the goals of the program. The importance of a concise, informative Project Summary cannot be overemphasized.

Title: Enhancing Educational Outcomes For Plant Genetic Resources Conservation And Use

PD: Byrne, Patrick F.	**Institution:** Colorado State University
CO-PD: Munoz-Amatriain, Maria	**Institution:** Colorado State University
CO-PD: Zarestky, Jill	**Institution:** Colorado State University
CO-PD: Suza, Walter	**Institution:** Iowa State University
CO-PD: Volk, Gayle M.	**Institution:** U.S.D.A.-A.R.S
CO-PD: Gardner, Candice	**Institution:** U.S.D.A.-A.R.S
CO-PD: Kinard, Gary	**Institution:** U.S.D.A.-A.R.S

The genetic diversity available through the USDA-ARS National Plant Germplasm System and similar organizations is essential for crop improvement and food security. However, high-quality training materials on management and use of plant genetic resources (PGR) is lacking. Our long-term goal is to expand the agricultural workforce that is well trained in subjects relevant to PGR acquisition, preservation, distribution, evaluation, and utilization. Specific objectives are (1) to create an administrative framework for prioritizing, developing, reviewing, and distributing PGR learning materials; (2) to develop an organized series of learning resources (videos, ebook chapters, images, etc.) covering PGR topics; (3) to establish an online repository to host, organize, and track usage of the developed content; (4) to develop and offer three 1-credit graduate-level modules at Colorado State University on PGR conservation and use in plant breeding and genetics; (5) to disseminate the developed materials broadly to communities of interest, including Tribal Colleges and 1890 Land Grant Universities. Two graduate students will help create and evaluate the effectiveness of learning resources, as well as activities for students participating in course modules, thereby incorporating a strong leadership development component. We envision that the materials developed in this project will be widely incorporated into graduate and undergraduate agricultural and bioscience courses, thus enhancing the understanding of crop genetic diversity and its importance in global food security. We believe this project will improve the quality of instruction on PGR topics (HEC Goal 1) and attract a wider range of students to FANH sciences (HEC Goal 2).

Response to previous review (Proposal 2018-05500)

A related proposal (Planning Activity for a Multi-Institution Genebank Training Program, Proposal 2018-05500) was submitted to the 2018 Higher Education Challenge Grant Program. Although this proposal requests a CG2 grant rather than a planning grant, the theme, collaborating institutions, and many of the Co-PI's are the same as last year's grant.

Positive aspects of the proposal. We appreciate the panel's overall support for a training program on genebanks and plant genetic resources. The review highlighted the proposal's strong letters of support, experienced team members, and the potential to reach a large number of students and faculty. Most of these same features are retained in the current proposal.

Negative aspects of the proposal

Need for a planning grant was not justified. The panel felt that the need for a year-long planning activity was not well justified, given that a NIFA-funded workshop had already been held. We agree that the groundwork for a training program was laid at the workshop in April, 2018. Based on the momentum generated by that event, we were able to continue planning and other preliminary activities, including conducting an online survey, with existing resources.

Value of a 1-credit course was not evident. A 1-credit course was proposed as an example of the kind of programming that would be produced in a fully funded project. In the current proposal, we have expanded the intended course to three 1-credit graduate-level modules. In addition, learning materials on an array of plant genetic resource topics will be produced.

How this project supports institutional long-range goals was not described. This is now described in section 1.c. of the proposal.

Unclear how leadership skill development will be incorporated. Leadership skills for the two graduate research assistants (GRA's) will be developed through a combination of experiential activities (planning and designing course content; developing videos; supervising undergrads; taking part in project evaluation), as well as formal training on leadership concepts and practices.

Would be helpful to involve personnel with teaching and learning credentials, as well as leadership studies. The proposed project involves Co-PI Dr. Jill Zarestky, with extensive experience in STEM teaching and learning theory, and consultant Dr. Deana Namuth-Covert, an expert in online course design and delivery.

Cover page

Project Title: Enhancing Educational Outcomes for Plant Genetic Resources Conservation and Use

Project Director: Patrick Byrne, Colorado State University

Co-PI's:

Maria Munoz-Amatriain, Colorado State University

Jill Zarestky, Colorado State University

Walter Suza, Iowa State University

Gayle Volk, USDA-ARS

Candice Gardner, USDA-ARS

Gary Kinard, USDA-ARS

Education Need Areas:

a. Curriculum Development, Instructional Delivery Systems, and Expanding Career Opportunities

c. Facilitating Interaction with Other Academic Institutions

Projected number of students to be served: 1,500

Primary Discipline Code & Academic Discipline: P – Plant Sciences and Horticulture

Grant Type: Collaborative Grant Type 2 (CG2)

Total Funds Requested: $749,443

Funds to Colorado State University: $518,357

Funds to Iowa State University: $139,692

Funds to USDA-ARS: $91,394

Partners: Colorado State University; Iowa State University; USDA-ARS

Enhancing Educational Outcomes for Plant Genetic Resources Conservation and Use

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Project Narrative

1. Potential for Advancing the Quality of Education; Significance of the Problem

a. Identification of Educational Problem and Project Impact

Qualified personnel dedicated to plant genetic resources (PGR) management and utilization are as necessary for food security as the PGR themselves. The U.S. PGR management community is experiencing unprecedented generational change in personnel, with as many as one-third of the scientific and curatorial staff of the U.S. National Plant Germplasm System (NPGS) potentially retiring in the next few years (Peter Bretting, USDA-ARS Office of National Programs, personal communication). This challenge is faced by global PGR organizations as well. To our knowledge, U.S. universities do not currently offer readily available PGR management courses or degree programs that could serve as a foundation for training the next generation of U.S. PGR managers. The proposed genebank training program, therefore, is a new higher education initiative that will capture and transfer a vast amount of institutional knowledge to the next generation of PGR scientists from many disciplines, who will become the caretakers and customers of the NPGS collections. The innovative format will engage, inspire, and educate those who participate in the program.

The proposed project will develop learning materials focused on plant germplasm conservation and utilization, and will target undergraduate and graduate students in the agricultural and biological sciences. The need and broad outline for such training materials was discussed at a workshop sponsored by a 2018 NIFA Conference Grant (http://genebanktraining.colostate.edu/). Thirty-one representatives from USDA-ARS, USDA-NIFA, land-grant universities, the seed industry, international genebanks, a botanic garden, and a non-governmental organization (NGO) convened at the USDA-ARS National Laboratory for Genetic Resources Preservation (NLGRP) in Fort Collins, CO April 24-26, 2018. The group discussed the needs, pedagogical approaches, delivery platforms, educational content, and mechanisms for sustaining a future PGR management training program (Volk et al., 2019). The workshop participants concluded that a resource library of learning objects should be developed and made freely available through a training website (Figure 1). The website would also provide links to national and international programs, documentation, and other available information. This “Resource Library” of training materials would be utilized to develop curriculum for existing or newly developed courses.

b. Project Justification: Summarize the body of knowledge justifying the need for the proposed project

Plant genetic diversity is the raw material upon which progress in crop improvement and global food security depends. The U.S. NPGS is among the world's largest collections of PGR, maintained at 20 locations throughout the U.S. The NPGS conserves nearly 600,000 accessions representing over 15,000 species, and plays an important role in U.S. and global agriculture by distributing 250,000 germplasm accessions annually (Byrne et al., 2018). Most accessions are provided to researchers for evaluation and development of cultivars with improved resistance to biotic and abiotic threats, product qualities, and enhanced yields. NPGS distributions also support ethnobotanical, archaeological, biochemical, and other research objectives, and occasional repatriation of germplasm to countries of origin or other genebanks when their PGR are lost. It is critical to have qualified, trained personnel maintaining the diverse NPGS collections. Curatorial staff need the most effective technologies and management techniques to ensure that materials are healthy, true-to-type, well-documented, and available for future generations. Although some educational materials exist on PGR topics, there are gaps in their coverage, they are scattered across multiple sources, and are not available to all learners.

The need for a training program in PGR management was recognized by members of the National Plant Germplasm Coordinating Committee (NPGCC, a USDA-sponsored multi-state committee) at their 2017 annual meeting. NPGCC members concluded that the ongoing challenge of training NPGS curators, research leaders, and support staff will become more acute as the current wave of retirements continues and grows over the next 5-10 years. The enthusiasm for the 2018 Plant Genebank Training Workshop in Fort Collins validates significant demand/interest in the proposed learning resources and indicates that university, industry, and non-profit groups will quickly use and adapt these resources.

An online survey was conducted in March 2019 to identify the specific topics on which training materials are needed and the preferred delivery methods. Survey feedback guided the development of this HEC proposal's objectives and training topics, and a manuscript analyzing the results has been submitted to Crop Science (Volk et al., submitted). A total of 425 survey responses were received from the genebanking, academia, NGO, and private sector communities, both national and international. The following statements were either "strongly agreed" or

"agreed" with by most respondents: 1) there is a shortage of high-quality learning materials on PGR; 2) availability of high-quality learning materials on PGR would provide information useful to me in my current position; and 3) availability of high-quality learning materials on PGR would be useful in teaching or providing information to others.

The survey asked the respondents to identify the primary audiences that would benefit from training materials. Over 50% of the respondents stated that the following audiences would benefit: myself, my employees/colleagues, graduate students/postdocs/visiting scientists, undergraduate students, genebank personnel, commercial seed/crop breeding/crop production companies, and seed savers/heirloom seed/fruit organizations. The employers of these audiences include USDA, universities, botanic/public gardens, seed/nursery/breeding companies, non-profit plant conservation organizations, government agencies, and Native American tribal organizations. Representatives of native peoples frequently seek repatriation of hereditary plant genetic resources and/or training in their maintenance. There are many other similar international organizations that would benefit from the training materials.

All respondents expressed a high interest in training related to accessing information associated with genebank accessions, crop wild relatives, genotyping and phenotyping. Respondents from academia also considered pre-breeding a priority topic. The private sector expressed particular interest in requesting and distributing genetic resources and prebreeding. NGOs emphasized collection gap analyses, explorations, germplasm preservation, intellectual property, and regulations as priorities. Genebank employees expressed interest in germplasm preservation, intellectual property, and general concepts related to plant genetic diversity. Figure 2 provides the sum of high and medium response percentages across various categories of respondents, demonstrating strong interest in all the training topics that were listed in the survey.

c. Institutional long-range goals

CSU's long-range goals, as described in the 2016 Strategic Plan (Colorado State University, 2016) include the following items related to this proposal:

- Increase undergraduate and graduate enrollment of underrepresented students.
- Increase the availability of online credits and degree programs, and improve learner outcomes in distance-delivered programs.
- Increase partnerships to further the internationalization of CSU.

- In the research realm, CSU's major initiatives include Food/Water/Energy, Climate Change, and Environmental Sustainability.

Iowa State University's mission (Iowa State University, 2017) is to 'create, share, and apply knowledge to make Iowa and the world a better place.' ISU goals pertinent to this project are:

- Provide 'an exceptional education offering practical, global, and leadership experiences that shape well–rounded citizens and informed critical thinkers'.
- Enhance the university's research profile for the grand challenges of the 21st century.
- Identify/invest in interdisciplinary priority areas.
- Enhance and cultivate life experiences for all in a safe, welcoming, and supporting educational environment.

The proposed project addresses the goals of these universities by establishing three new online course modules and creating an array of learning objects on the inherently interdisciplinary, globally relevant subject of harnessing PGR for crop improvement. If successful, we believe the developed materials will help attract learners beyond the traditional clientele of agriculture-related courses.

d. Innovation

The proposed project is innovative, unique, and inclusive. There are currently no coordinated efforts or shared resources to deliver knowledge and training on PGR topics. The current information is widely dispersed and fragmentary, with many topics either not addressed or outdated. The novelty of the proposed project resides in a multi-institutional approach, making it possible to draw instructors and materials from experts at different institutions to deliver a coordinated training program. It will be inclusive, because the online delivery platform for learning objects and modules will facilitate participation by students and interested audiences in the U.S. and globally. U.S. government standards will be followed so that the materials developed are accessible to persons with physical challenges to the use of traditional audio and visual presentation content.

e. Multidisciplinary and/or Problem-based Focus

Plant genebanking may be among the most multidisciplinary fields in the plant sciences. Genebank scientists come from many disciplines including agronomy, botany, horticulture, plant breeding, genetics, molecular biology, plant pathology, plant physiology, entomology,

bioinformatics, and geospatial sciences. It is necessary for these scientists to understand and make use of taxonomic, genetic, phenotypic, and geospatial information as well as complex agronomic/horticultural practices to propagate and distribute diverse collections of the world's agriculturally and economically important plants, as well as to develop collections to represent that diversity. Skills are required to manage PGR information and workflows, develop and follow standard operating procedures, and conform to the relevant federal, state, and international regulations and access regimes. Integrating a wide variety of tools and technologies for effective pre-breeding is essential. Knowledge of multiple disciplines will be assembled to prepare future professionals and expand the skills of the current workforce.

2. Proposed Approach and Cooperative Linkages

a. Plan of operation and methodology

This proposal has developed a unique collaboration between university and USDA scientists. The NPGS participants will focus on developing training materials related to the conservation and utilization of PGR (Volk, Gardner) and making those training materials publicly available (Kinard). University experts in plant breeding and genetics from CSU (Byrne, Munoz-Amatriain) and ISU (Suza) and distance education consultant (Namuth-Covert) will develop training materials, incorporate them into lessons and course modules, and teach the content.

Goal and Objectives: The long-term goal of this project is to expand the agricultural workforce that is well trained in subjects relevant to the acquisition, preservation, distribution, evaluation, and utilization of PGR and associated information. Specific objectives are listed below and the relationship among them is diagrammed in Figure 3.

1) To create an administrative framework and conceptual pipeline for prioritizing, developing, reviewing, and distributing learning resources on PGR;
2) To develop an organized series of learning resources (videos, ebook chapters, images, etc.) covering priority PGR topics;
3) To establish an online repository to host, organize, and track usage of the developed content;
4) To develop and offer three 1-credit graduate-level online course modules at CSU on PGR conservation and their use in plant breeding and genetics;
5) To disseminate the developed materials broadly to communities of interest, including Tribal Colleges and 18090 land-grant universities.

Objective 1) To create an administrative framework and conceptual pipeline for prioritizing, developing, reviewing, and distributing learning resources on PGR

An Advisory Council with knowledge of PGR and online education topics will be established to guide implementation of the project. The advisors will provide guidance on content development, peer review the learning materials prior to posting, help disseminate the developed materials and promote their usage, and develop strategies to maintain support for this initiative once the project funding ends. We envision a council of 7-8 members that include faculty members engaged in teaching at land grant universities, both on-campus and online). Dr. Matthew Blair of the 1890 land-grant institution Tennessee State University has agreed to serve as an advisor. Additionally, we will invite representatives from the private sector, an NGO (e.g., a botanical garden), the USDA NPGS, and the international genebank community. The council will convene twice yearly via conference call to discuss progress, review plans for the next six months, help resolve problems, and confer on other issues that may arise.

We envision a learning object development workflow process as diagrammed in Figure 4. The content review process that will be similar to that of the eXtension model or the Journal of Natural Sciences Education review processes before content is posted, i.e., an internal review is performed by three qualified people: one content expert, one teacher of the content, and one IT/instructional designer.

Objective 2) To develop an organized series of learning resources (videos, ebook chapters, images, etc.) covering priority PGR topics

University and USDA partners will develop high-quality, accurate, interactive, and informative training materials relating to PGR conservation and utilization. As illustrated in Figure 4, in addition to developing new content, we will also incorporate any relevant and updated information that is already available online by obtaining permission for its use (if necessary) and posting links to it on an organized, publicly available website.

We propose to develop the new educational content as learning objects, small stand-alone and portable packages. These learning objects will be used to develop academic course modules for Objective 4, and also made freely available as open education resources for use in additional courses at other institutions, as well as in-house training at USDA. Based on the 2019 survey results, we will create new content in several formats, including short, online videos covering

specific subjects; eBook chapters that provide videos, images, and interactive text organized to cover a topic; and stand-alone images and text documents, for example on best management practices. Learning object topics are listed in Table 1. A conservative estimate is that we will produce 20 of these objects each year. Most of the new content will be conceptual, and appropriate for the upper-undergraduate or graduate student audience. It will also be highly relevant for current genebank and university scientists and technical staff, who wish to learn new skills. Some of the content may be more procedural, demonstrating and explaining specific methods and techniques relevant for effective PGR genebanking.

The piloted eBook chapter platform (Pressbooks) will allow the content developers and users to access related modules of information together in an organized package. Each learning object will be a separate chapter within the eBook that will be linked from the PGR Training Resources website (Objective 3). Instructors can choose to use selected chapters or the entire books in their courses. The eBook chapters also have the benefit of exporting as PDFs so that content can be read and accessed offline and the original links to the videos will be retained in the downloaded PDF. Additional chapters can easily be added to eBooks as time/resources allow. The specific eBook titles have not yet been identified, but it is conceivable that there will be eBooks focused on “Plant Genetic Diversity”, “Crop Wild Relatives: Collections and Use”, “Introduction to Genebanking”, “Genebank Management”, “Characterization and Evaluation of PGR Collections”, as well as many others.

We will focus content development on the subject material needed for the three 1-module courses to be taught at CSU (Objective 4), to ensure that we have a strong link between the content development and delivery components of this proposal. The first priority for content development will be materials needed for the new course modules. Over time, additional content will be developed that covers the subject more intensively. The learning objects that are developed in this HEC proposal will also be used in the Plant Breeding Education for Africa project at ISU (https://pbea.agron.iastate.edu/) and the Online Seed Technology Program at CSU (https://www.online.colostate.edu/certificates/seed-technology/).

There is vast expertise and institutional knowledge on PGR management available within the USDA-NPGS, and three of its scientists are included as Co-PI’s in the proposal. With the strong support of USDA-NPGS leadership (see letter by Dr. Bretting), we will work collaboratively with the NPGS sites to create training materials. Dr. Gardner will focus her NPGS coordination

efforts primarily on activities related to seed-based crops and the use of GRIN-Global. Dr. Volk will coordinate efforts amongst scientists at the NLGRP (seed and clonal preservation, seed testing, crop wild relatives) and at the NPGS clonal sites. Dr. Kinard will make the Germplasm Resources Information Network (GRIN) available as a long-term resource to help curate content and/or provide links to it. The university Co-PIs will also develop content, with a focus on the utilization of PGR. As needed, we will develop collaborations with industry, non-profit, academia, international, and other federal employees to acquire and develop training materials.

As a pilot, Dr. Volk, with guidance from Dr. Namuth-Covert, developed four training modules related to her research program in the spring of 2019 (http://genebanktraining.colostate.edu/trainingmaterals.html; Table 2). Although these topics are more specific and technically detailed than most of what will be provided through the HEC grant, they provided an excellent opportunity to explore content delivery programs and to develop a workflow process. Dr. Byrne used the same workflow process to make four YouTube videos related to wheat domestication and pre-breeding (Table 2). Based on what we have learned in these pilot projects, we will be able to launch this proposal immediately, if funded.

The content development will be coordinated by the HEC project scientists and the two project graduate students (graduate research assistants, GRA's) at CSU and ISU. First, subject matter experts convened by the HEC Co-PI's will determine overall learning goals for each overarching topic area, as well as specific objectives for each learning object. This will help to consolidate efforts and map out critical information to be provided, and the method for acquiring and presenting that information. The HEC Co-PI's will then make the necessary contacts and provide the coordination needed to develop and acquire the content.

Images and video will be captured in-house or with the assistance of videographers at ISU and CSU. Technical staff and HEC-funded undergraduate students will demonstrate PGR processes and procedures and will help create diagrams, illustrations, flow charts, etc. Text and video scripts will be developed by technical experts. Video editing will be performed by HEC-funded undergraduates. A half-time administrative professional at CSU will supervise learning object development by providing guidance and assistance for video editing, adding voice-overs and closed captioning, and uploading content to YouTube and Pressbooks. This person will also identify existing content related to PGR utilization. The AdminPro will work closely with Dr. Kinard's team to design and build the NPGS training website.

Leadership development. The two M.S. GRA's will be integral members of the project team and will have multiple opportunities to develop leadership skills. They will plan, research, and create learning objects on specific topics, under the mentorship of their advisors and with the assistance of undergraduate students whom they will supervise. They will collaborate in designing active learning components for the online courses. They will work with the evaluation specialist in assessing the effectiveness of the learning materials. In addition, they will participate in formal courses/workshops designed to enhance leadership skills, e.g., workshops offered by the SLiCE program at CSU (https://lsc.colostate.edu/slice/slice-leadership/the-real-experience/).

Objective 3) To establish an online repository to host, organize, and track usage of the developed content

The USDA-ARS Database Management Unit (DBMU) of the National Germplasm Resources Laboratory in Beltsville, MD, will develop and publish a new "Plant Genetic Resources Training Resources" page as part of the NPGS section (https://www.ars-grin.gov/npgs/index.html) of GRIN. The existing training materials that are identified and the new content that is developed with this grant will be made publicly available through these new pages. This will include uploaded images, text/PDF documents, videos, etc. The learning objects developed using Pressbooks will be publicly available through CSU and linked to by the NPGS PGR Training Resources page. The new website will be organized in an intuitive, user-friendly manner. The DBMU will use web analytics (e.g., Google Analytics) to document the access and use of the materials that are made available.

In addition to hosting on the GRIN site, the learning objects will also be made available to educators through other repository sites to maximize access. These sites include Open Educational Resources Commons (https://www.oercommons.org/), a digital library with free access to teaching resources for instructors and curriculum developers; and MERLOT (https://www.merlot.org/merlot/), a portal providing access to online learning materials. Videos will be hosted on a YouTube Channel (https://www.youtube.com/) for the general public. Select materials will be submitted for peer review in the Journal of Natural Sciences Education (https://dl.sciencesocieties.org/publications/nse).

Objective 4) To develop and offer three 1-credit graduate-level online course modules at CSU on PGR conservation and their use in plant breeding and genetics

The three graduate-level course modules will be developed and taught by Co-PI Munoz-Amatriain, with assistance from other Co-PI's and the GRA's. The learning objects created in Objective 2 will be the foundation for these courses. The three modules in this series can be taken individually or completed as a series. These modules will be 1) Plant Genetic Diversity and Crop Domestication; 2) Germplasm and Genebank Management Operations; and 3) Utilization of PGR for Gene Discovery and Crop Improvement. A more detailed listing of module topics is found in Table 1. The courses will be available through CSU Online (https://www.online.colostate.edu/) to CSU students, as well as those not enrolled at CSU, either for credit or non-credit. An out-of-state tuition premium is not charged for CSU Online courses.

Instructional Design

Quality Matters instructional design principles will be followed for these course modules (https://www.qualitymatters.org/). Students will be assigned to work through a set of learning objects each week, along with reading and discussing relevant research articles supplementing the main topic. Using the Pressbooks platform, individual lessons will be created by packaging the learning objects (such as videos, animations, and photos) with supporting text, along with interactive quizzing elements to help the students process the new information they are learning. To foster soft skills development (e.g., communication, leadership, and teamwork) each course module will incorporate a problem-based activity for student groups to work through and present, either synchronously through a video conference system such as Zoom or asynchronously by recording and posting videos in the discussion board area.

Each week's content will apply a problem-based approach in which students learn by solving complex problems that do not have a single solution. We believe this is relevant preparation for the challenges they will face in their PGR-related careers. Such an approach is intended to build flexible thinking and content knowledge and self-directed learning behaviors (Hmelo-Silver, 2004). All learning materials will be designed to work in either a fully-online stand-alone course or for use as embedded material in a "flipped" university course (a learner-centered model in which content presentation takes place outside class, and discussion or homework takes place in the classroom; Akcayir and Akcayir, 2018), creating flexibility for instructors and availability for learners worldwide (Donnelly, 2010). Learning outcomes will be evaluated based on weekly quizzes (30%), a project report (30%), and a final exam (40%). As a prerequisite, students will be expected to have basic knowledge of genetics and biology/botany.

Module organization (See Table 1 for more details)

Module 1, Plant Genetic Diversity and Crop Domestication. After completing this module, students should understand crop evolution and domestication, and concepts such as genetic bottlenecks and gene pools. They should be able to explain the importance of PGR for crop improvement and to organize information from different viewpoints on biodiversity in relation to sustainable agriculture and food production challenges. The project-based learning component of this module could be a report (video or text based) in which the student selects a crop wild relative native to North America and reviews its genetic diversity, role with respect to indigenous peoples, and relationship with the domesticated crop.

Module 2, Genebank Management Operations. Upon completing this course, students will understand the history, theory, operations, and logistical challenges of *ex situ* genebank management. As part of this module, students will be required to interview an expert in plant genebank management or PGR utilization to learn more about genebanking professions.

Module 3, Utilization of PGR for Gene Discovery and Crop Improvement. Examples will be drawn from a variety of crops, from the familiar (wheat, sunflower, tomato) to the more exotic (amaranth, taro, cassava). After this course module, students will be able to understand the benefits and challenges of using exotic germplasm for crop improvement, the information resources available for targeting useful PGR and traits, how to apply statistical methods to decipher the genetic architecture of traits, and how to identify the best pipeline for trait introgression. Students will be asked to identify a genebanking "success story" and describe the impact of a genebank accession in the form of a public-friendly presentation that could then be converted into a learning object (with permission and through student collaboration). This will help build a library of plant genebanking success stories for diverse groups of stakeholders.

Plant Breeding Education for Africa at ISU

Co-PI Suza coordinates a multinational project called Plant Breeding E-Learning in Africa (PBEA, https://pbea.agron.iastate.edu/). PBEA builds on ISU's expertise with online plant breeding education by developing and delivering open education resources to faculty and students in Africa. These learning resources are also freely available to users in the U.S. and around the world. In the past 6 years, the use of PBEA materials has expanded from three to about 20 countries in Africa, as well as in Latin America and South East Asia. Feedback from African faculty and students confirms that these materials are valuable for their teaching and

learning needs. For students and self-learners in developing countries, these open education resources mean less money spent on course materials and books. In addition, they represent an opportunity to more easily upgrade outdated content. New topics and sections can be added and enhanced, thereby creating continuous improvement in learning objects. That type of exposure and collaboration is not possible with materials that reside on a local computer or only in print.

This proposed project will leverage lessons learned by the PBEA team to support our efforts to create similar materials for PGR. The learning resources developed through this grant will be offered online, freely and openly for educators, students, and self-learners to use and reuse for teaching, learning, and research. We envision that images and experiences shared by our African colleagues on their use of PGR will enrich the content of the U.S. courses.

Learning object use in other courses

Many other courses in the agricultural and biological sciences address biodiversity, global food security, or crop improvement. Two examples are the CSU courses Plants & Civilization (300 students each semester) and General Crops (60 students in fall). Instructors of these courses have expressed their enthusiasm for our learning materials and their willingness to use them in their courses (see attached letters of support from Norton & Jahn and Schipanski). We will promote the use of these materials in introductory biology and plant science courses, especially at Tribal Colleges and 1890 universities, in hopes of attracting a wider range of students to the food and agricultural sciences.

Learning objects created in this project that address topics in seed germination and viability testing will be used to update the Seed Technology Education Program courses at CSU (https://seeds.agsci.colostate.edu/step-into-the-world-of-seeds/welcome/; see letter from Rick Novak). They will also benefit the ISU Seed Science Program (https://www.seeds.iastate.edu/).

Objective 5) To disseminate the developed materials broadly to communities of interest, including Tribal Colleges and 1890 land-grant universities

Our dissemination strategy will take advantage of multiple communication methods to reach a broad audience of potential users. Each Co-PI and GRA will attend a professional conference (e.g., annual meetings of the Crop Science Society of America, International Society for Seed Science, American Society for Horticultural Science, American Public Gardens Association, or National Association of Plant Breeders) to give an oral or poster presentation about the learning

materials and courses. Announcements will also be made through newsletters and email lists of professional societies, USDA-ARS, and PGR interest groups. Webinars will be developed to demonstrate the learning materials, ideally under the auspices of eXtension or a professional society. Manuscripts will be prepared when enough evaluation data has been gathered to discuss the effectiveness of the developed materials. As explained in Objective 3, the learning resources will be made available through other repository sites in addition to GRIN. Appropriate keywords will be incorporated into titles for identification through online searches, and links to training resources and/or course modules will be incorporated into email signatures. Finally, the communications units of USDA, CSU, and ISU will employ social media to spread the word.

b. Timetable

Milestone	**Year 1**				**Year 2**				**Year 3**			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Start-up	X											
Learning materials developed and posted*	X	X	X	X	X	X	X	X	X	X	X	X
GRA's hired			X									
Dissemination					X	X	X	X	X	X	X	X
Online courses approved				X								
Online courses offered							X	X			X	X
Evaluation					X	X	X	X	X	X	X	X
Close-out												X

* More detailed target dates for materials development are included in Table 1.

c. Evaluation and Assessment Plans

The evaluation plan consists of two major components: (1) evaluation of student learning and engagement and (2) evaluation of the impacts on students' professional pathways.

Component 1. To evaluate student learning, we will utilize the data analytics (Greller & Drachsler, 2012) capabilities of the online content delivery system, Pressbooks, and the learning management system, Canvas. Both the Pressbooks and Canvas platforms allow student user data to be tracked. Data from the systems will be derived from student interaction with the content

modules and elements of the flipped course design. Types of data include the elements students click on and access, how long they view or interact with a module or learning object, and can be coupled with student scores on quiz questions or other assessments. Nugent et al. (2016) found that the same learning objects could effectively be used in a variety of class formats. In the data collection process, we will monitor instructors' use of the materials to track class formats and control for those differences in the analyses. Across all instructors, common content questions will be used on assessments to compare student learning.

By combining data from the learning objects and independent measures of content learning, the project team will be able to analyze the relationships (if any) among design of learning objects, students' interaction and engagement with the learning objects, and subsequent changes in content knowledge. Student preferences will also be gauged by surveys of their perceptions and satisfaction with the online content. Thus, we will be able to determine the efficacy of the learning objects in improving student content knowledge and engagement.

Component 2. An evaluation of the impacts of materials on students' professional pathways will address the program goals of enhancing quality of instruction and increasing the number and diversity of students in the field. For example, for undergraduate students, the proposed materials may serve as a recruitment strategy for further food, agricultural, natural resources, and human sciences (FANH) courses or career choices. As students will be exposed to this content earlier in their academic career than otherwise anticipated, they have an opportunity make choices to explore the related disciplines to which they would previously not have been exposed. Similarly, as this content will reach a broader audience than current practices allow, the opportunity to recruit diverse and underrepresented individuals is increased.

Building from the learning analytics from component (1), we will track student interest in related career paths to measure the subsequent impact of the content learning on professional pathways. To do so, we will track student interest in related career pathways as indicated by institutional data. These data will include demographics, subsequent course selection, major changes, and employment post-graduation, items already tracked by the participating institutions. A limitation of this approach is that such data exist only for students in for-credit courses or degree-programs. While the duration of this proposed project is a limitation, the data should still provide preliminary indications of impact to inform future diversity and recruitment efforts. All

data collection processes will be conducted in accordance with consent protocols and research plans approved by the Institutional Review Boards of research and partner institutions.

d. Dissemination plans. Described in Objective 5 above.

e. Partnerships and collaborative efforts

The proposed partnership brings together organizations with a wealth of experience in classroom and online instruction, PGR management, plant breeding, and allied disciplines. The collaborative arrangement between CSU and ISU is described in the Collaborative Arrangement attachment. The proposed project will strengthen the relationships between two land-grant universities and adjacent USDA-ARS germplasm facilities, through the participation of several USDA scientists as Key Personnel. We expect that collaborators from other academic institutions as well as other USDA-ARS units will also participate in this planning effort.

f. Potential pitfalls, limitations, and alternatives

As this is a distributed effort, there is the possibility that the resulting products will be uneven in format, quality, or thoroughness. We will establish design guidelines early on and will rely on review by the Co-PI's and Advisory Council to guard against this possibility. The impact of the project will depend on how widely the developed resources are used by instructors in their courses. We will have no direct control over this, other than making the materials as informative, current, and engaging as we can, and announcing their availability widely. An alternative would be to establish more traditional face-to-face courses at CSU and ISU, but the number of students that benefit would be much more limited.

3. Institutional Capacity and Capacity Building

a. Institutional/organizational commitment and capability

CSU is dedicated to 'excellence across the entire spectrum of undergraduate and graduate student learning'. It is committed to inclusive access and to providing research and service for the benefit of the citizens of Colorado and beyond. The University, the College of Agricultural Sciences, and the Department of Soil and Crop Sciences have all committed to increase the number of distance education courses offered and to improve the learning outcomes of students in those courses. At the University level, significant resources have been invested in The Institute for Learning and Teaching and CSU Online. At the college level, an instructional technology and

design specialist has been hired to provide guidance for online course development. The Department is currently developing online versions of two large enrollment courses: Introductory Soils and General Crops. Another example of the Department's commitment to this project's goals is the recent recruitment of a faculty member (Co-PI Munoz-Amatriain) dedicated to germplasm evaluation and strengthened collaboration with USDA-NPGS scientists.

ISU, the College of Agricultural and Life Sciences, and the Department of Agronomy have two successful, long-standing online programs. One is the Master of Science in Agronomy (https://masters.agron.iastate.edu/), with an average of 100 students in courses every semester. The other is a Master of Science in Plant Breeding (http://agonline.iastate.edu/programs/plant-breeding-ms), with 9 years' experience and 10 online courses. More recently the Department has implemented an e-platform in Plant Breeding (PBEA, discussed in Obj. 4 earlier) to assist African universities train students. The combined experience drawn from these programs will be directly applicable to the envisioned genebank management training effort. As pointed out in the letter by Thomas Lübberstedt, there will be various opportunities for interaction between the existing distance and online programs and the proposed project.

b. Institutional/organizational resources

CSU, through The Institute for Learning and Teaching (TILT, https://tilt.colostate.edu/), offers a wide array of resources and services related to course design and development, teaching improvement, and learning strategies. The institute offers seminars and workshops throughout the year. The College of Agricultural Sciences employs an instructional technology and design specialist to assist with learning management software, online course delivery, and video production services. CSU Online (https://www.online.colostate.edu/) manages, promotes, and delivers online courses for the CSU campus.

ISU and the Department of Agronomy have an in-house group of professionals experienced in developing online platforms for course delivery. They are available for consultation to develop the envisioned learning objects for the genebank management training program. There is also a strong group dedicated to excellence in teaching, part of the office of the Associate Provost for Academic Programs and Teaching, which regularly offers training courses to improve teaching, delivery, and appropriate instructional formats.

USDA-ARS NPGS has a network of 20 genebank locations throughout the U.S. Personnel at these locations have expertise in the technical and innovative aspects of plant genebank and PGR management, as well as conceptual areas of plant genetic diversity, domestication, crop wild relatives, phenotyping, genotyping, and information management. NPGS sites will provide learning object content in the form of text, images, videos, etc., that will be converted into learning objects by HEC project personnel. Most of this content will be generated in-house provided by USDA employees and/or their university, industry, and NGO collaborators.

c. Academic enhancement

CSU is a leading land-grant university in the semi-arid West, with well recognized programs in plant breeding and genetics, agroecosystems, natural resources, and environmental sustainability. The learning resources developed in this project will enhance instruction of courses in all of those areas, and promote greater interaction between CSU and USDA-ARS scientists at the NLGRP. We believe the resources developed will be widely used by other organizations beyond ISU and CSU, both in the U.S. and abroad.

ISU and CALS are both ranked among the 10 most prestigious institutions in the U.S. for training of students in agricultural fields. The online programs in Agronomy, Plant Breeding, and Seed Science are important components of this ranking. The addition of learning resources on genebank management/PGR is a natural follow-up on this path. The effort is also consonant with the strategic plan and mission of ISU, about striving for the best scientific education for students in the sciences and agriculture-related fields, for the betterment of world needs. The administrative and collaborative association that ISU has established with the USDA-ARS Plant Introduction Station in Ames, contributes to strengthening the ties between ISU, the agricultural field, and the national interest in food security.

Although USDA-ARS is not an educational institution per se, NPGS locations host hundreds of visiting scientists and students (internships and part-time employment) every year. The NPGS provides a tremendous amount of on-the-job training for new employees and students because learning resources are not currently available. Access to a new online modular courses as well as freely available learning objects will significantly improve the training opportunities that are available within the NPGS.

d. Continuation plans

The academic portion of the program (CSU course modules) will generate cost recovery through tuition revenue. CSU policy returns about 50% of online course tuition to the instructor, which provides an incentive to update and improve course content. The GRIN information management system is supported long-term by USDA-ARS base funding, and therefore, the continuation of the online repository is assured for the foreseeable future. For creation of new or updated learning objects, sponsors with an interest in PGR issues will be sought, for example, the Agronomic Science Foundation, the American Seed Trade Association, or Crop Trust.

4. Key Personnel

PD: Patrick Byrne, CSU Department of Soil and Crop Sciences, teaches and conducts research in plant breeding and genetics. His research on wheat genetics has included extensive evaluation of crop landraces and wild accessions. He teaches an online course and face-to-face courses. He will have overall responsibility for coordinating implementation of the project, managing the budget, providing oversight on development of training materials, and contributing directly to content development of selected topics.

Co-PI: Gayle Volk, USDA-ARS NLGRP, Fort Collins, CO, focuses primarily on improving the conservation and preservation of clonally propagated crops. She co-organized the NIFA-sponsored workshop on genebank management training, and co-authored (with Dr. Byrne and others) a Crop Science review article on PGR and the Plant Genetic Resources Training Survey. She has also developed an eBook chapters that utilize videos, images, and text to provide training information. She will be responsible for coordinating USDA-NPGS efforts to develop learning objects relating to plant genetic resources conservation and use.

Co-PI: Candice Gardner, USDA-ARS and ISU Department of Agronomy is research leader at the North Central Regional Plant Introduction Station. Her research centers on characterization, evaluation, and utilization of PGR, particularly with maize, and technology integration. She shared authorship on the Crop Science review article cited above. Dr. Gardner will contribute to development of modules and training materials, especially for seed crops.

Co-PI: Gary Kinard, USDA-ARS, is the Research Leader for the National Germplasm Resources Laboratory (NGRL) in Beltsville, MD, which supports the entire NPGS. NGRL

operates the GRIN system a stable, long-term, public domain, and widely recognized source of information on PGR, in addition to searchable databases for ARS collections. Dr. Kinard and his IT staff will make learning content available as well organized and curated pages on GRIN and/or links to other content repositories as needed. Dr. Kinard and other NGRL scientists will also provide expertise on several PGR topic areas including plant explorations and exchanges, crop wild relatives, taxonomy, and international germplasm movement/phytosanitary issues.

Co-PI: Maria Munoz-Amatriain, is Assistant Professor in CSU's Department of Soil and Crop Sciences and instructor of Principles of Genetics. Her research focuses on the identification of novel sources of variation for use in breeding programs. She has characterized diverse germplasm collections, including the barley and cowpea core collections. She will be responsible for the development and teaching of the three graduate-level online course modules at CSU, and the direct supervision and mentoring of the graduate student.

Co-PI: Walter Suza, Department of Agronomy at ISU, serves as Director of Plant Breeding Education for Africa. Before assuming this role, he interfaced between ISU plant breeding faculty and instructional technology groups in development of interactive online course materials in plant breeding. He worked previously with World Food Programme in Angola and UNICEF in Zimbabwe. Dr. Suza will develop instructional materials, make the materials available through the PBEA website, and serve as mentor for the ISU graduate student.

Co-PI: Jill Zarestky, CSU School of Education, is an Assistant Professor of Adult Education and Training. Her research focuses on STEM education and education for international development. Zarestky's expertise will bridge the gaps among the various facets of the project by making connections between educational theory and practical implementation, and types of learners, including graduate and undergraduate students, and practitioner and professional audiences. She will be responsible for conducting the project evaluation.

Consultant: Deana Namuth-Covert, Distance Education Director, College of Food, Agricultural and Environmental Sciences, The Ohio State University. Her current OSU contract ends in May, 2020, so she is listed here as a consultant. She has 20 years of experience teaching online, leading the creation of a plant science learning object repository, as well as leading teams

that research best practices in online learning. She will provide guidance on course design, and development and assessment of learning objects and online lessons.

5. Budget and cost-effectiveness

a. Budget. The PD and university Co-PI's will each receive modest compensation for their time (0.5 to 1 month of salary per year), while their actual time investment will be much greater. The USDA Co-PI's will provide their services without additional compensation from this grant, a bonus that will enhance the quality and relevance of the developed content. We have found that having effective administrative professional assistance is essential for this type of project that involves website maintenance, support for course development, creation of learning objects at multiple sites, dissemination of results, and travel arrangements. Inclusion of 7 months/year of AdminPro support will help us develop a coordinated, smoothly operating project. Participation of two GRA's will be a cost-effective way to research existing programs and develop and evaluate new content. It will also provide professional development experience for students interested in teaching as part of their careers. Allocation of funds among collaborating institutions is 69% (CSU), 19% (ISU), and 12% (USDA-ARS). This distribution reflects CSU's administrative role and course development responsibilities, ISU's role in developing learning objects, and USDA's reduced funding because Co-PI salary is not requested. The proportions of funds dedicated to each Educational Need Area are approximately 80% to Need Area (a) Curriculum Development, Instructional Delivery Systems ...; and 20% to Need Area (c) Facilitating Interaction with Other Academic Institutions.

b. Cost-effectiveness

The amount of professional staff time devoted to this project is far greater than what is requested in the budget. This is due to the participants' belief in the importance of the project's goals and the effectiveness of sharing the workload among many collaborators. As evidenced by the letters of support, there are many well qualified scientists ready to contribute to this proposed project without compensation, either by serving on the Advisory Council or previewing the materials developed in this project in their courses. If properly selected and mentored, the two graduate students will be cost-effective members of the project team, while receiving experience that will help advance their careers.

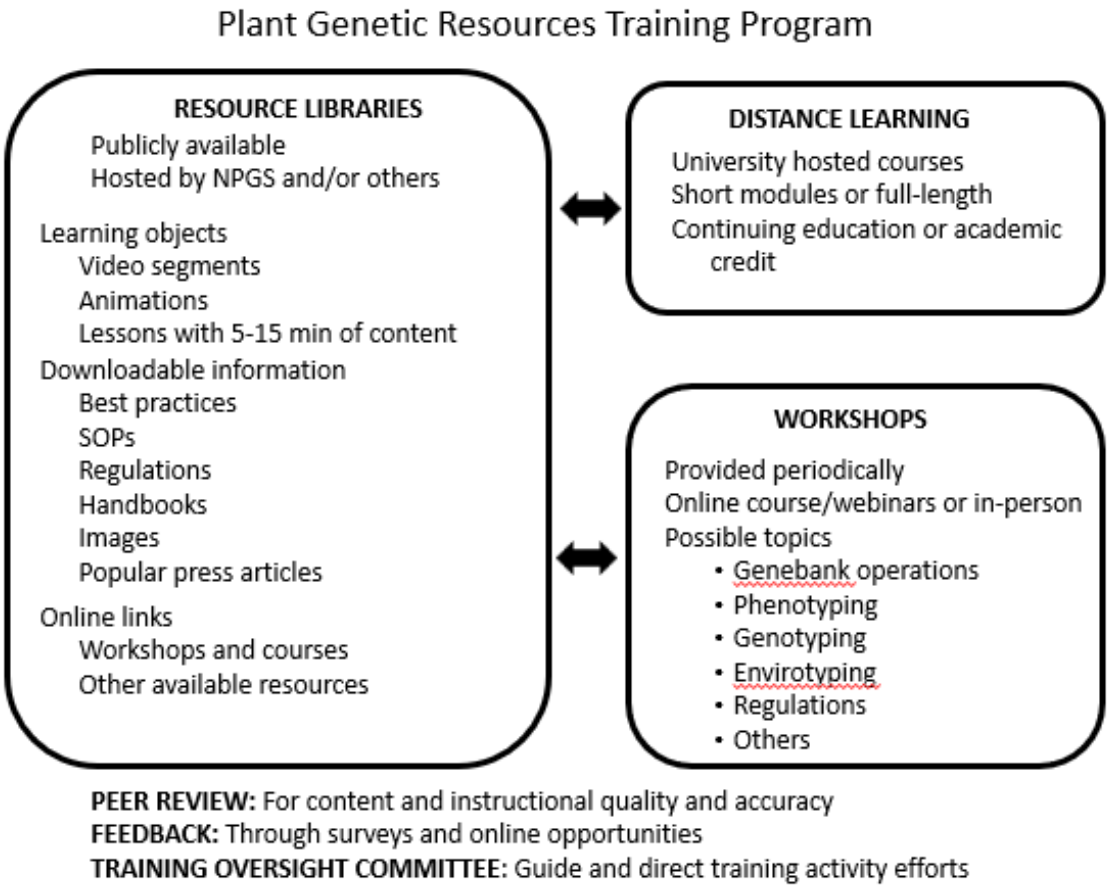

Figure 1. Components of a Plant Genetic Resources Training Program, as envisioned at the Genebank Training Workshop, April 24-26, 2018.

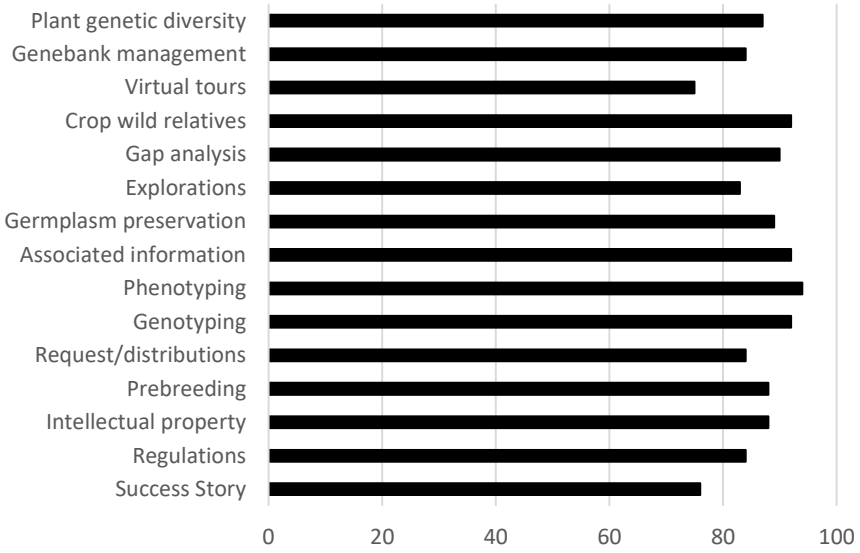

Figure 2. Sum of high and medium priority response percentages averaged across six institutional types.

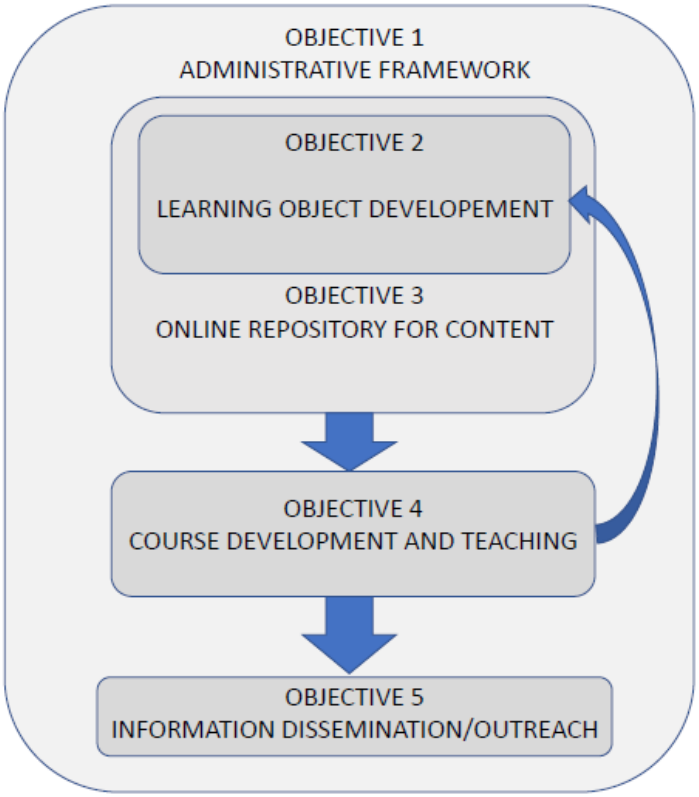

Figure 3. Diagram for the proposed approach/cooperative linkages showing the interactions between the objectives.

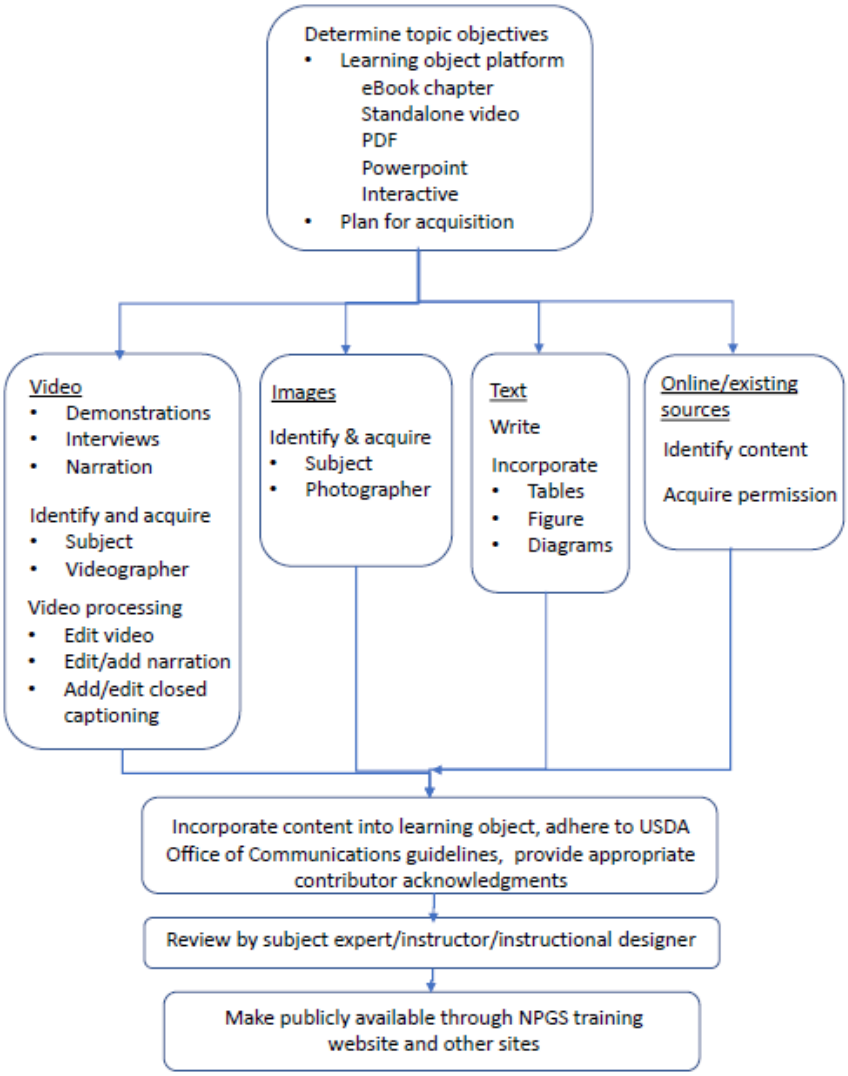

Figure 4. Proposed workflow for learning object development.

Table 1. Learning object topics organized by training module.

Learning Object Topics	**Co-PI Coordinator**	**Year**
Module 1. Plant Genetic Diversity and Crop Domestication		
Understanding biodiversity and genetic variation	CG,MMA	1
Origins of agriculture and crop domestication. Centers of diversity	GV	1
Impact of domestication and breeding on genetic diversity. Genetic bottleneck	MMA,CG	1
Gene pool concept	CG, GV	1
Crop wild relatives (CWR)	MMA,GV,CG	1,2
Genetic vulnerability and crop diversity	MMA,WS,GV	1
- Addressing crop production challenges		
- PGR in agricultural production and food systems		
- *De novo* domestication of plant species		
Module 2. Genebank Management Operations		
Scientific collections - their nature and purpose	GV	1
Early germplasm explorers and development of collections	GV,CG	1
Genebank landscape - US NPGS and international	CG	1
Access & benefits sharing, intellectual property restrictions	CG,WS	1
Acquisition of material: Planning, gap analysis, priority setting	GV	2
Collection activity: provenance and passport information, logistical considerations, distribution, import regulations	CG	2
Maintenance of germplasm collections: viability assessment, dormancy, propagation methods, cryopreservation, storage conditions, in situ vs ex situ	GV,CG	1,2,3
Evaluation of collections (in relation to genebank operations)	GV,CG,MMA	2
GRIN-Global & information resource utilization	GK, CG	2
Module 3. Utilization of Plant Genetic Resources for Gene Discovery and Crop Improvement		
Overview of genetic diversity, crop vulnerability and production challenges (some students may have not taken Module 1)	MMA,WS,CG	1
Genebanks as repositories of crop genetic diversity (overview of Module 2)	MMA,WS,GV,CG	1
Characterization/evaluation of germplasm collections	MMA,GV,WS,PB	1,2,3
Genotyping/sequencing and standardized phenotyping		1

Core collections		1
Population structure		2
Genome wide association studies (GWAS)		2
Genomic resources for candidate gene identification		2
CWR in crop improvement	MMA, CG, WS, PB	2,3
Pre-breeding strategies		2
Gene editing		2
Genebanking success stories	PB,GV	1,2,3
Impact of PGR utilization - Cost/benefit analysis	CG,MMA	2
Giving back to the genebank	MMA	2

Table 2. Examples of learning objects developed in Spring, 2019. All are accessible at http://genebanktraining.colostate.edu/trainingmaterials.html.

Developer	**Type**	**Topic**
Byrne	Video	Evolutionary history of wheat
Byrne	Video	D Genome diversity
Byrne	Video	Contrasting wheat traits
Byrne	Video	Bread Wheat x D Genome diversity
Volk	eBook chapter	Citrus shoot tip cryopreservation
Volk	eBook chapter	Citrus shoot tip micrografting
Volk	eBook chapter	*Prunus* shoot tip cryopreservation
Volk	eBook chapter	Apple dormant bud cryopreservation

Budget Justification

Personnel

Senior/Key Personnel ($78,846):
The PD (Byrne) requests salary for 0.5 of a month ($13,808/month base salary) per year during the life of the grant. He will have overall responsibility for coordinating implementation of the project, managing the budget, providing oversight on development of training materials, and contributing directly to content development of selected topics.

Co PI's Maria Munoz-Amitriain and Jill Zarestky will each be funded for one month of salary for each year of the project. Dr. Munoz-Amitriain ($9,966/month base salary) will be responsible for the development and teaching of the three graduate-level online course modules at CSU and the direct supervision and mentoring of the graduate student. Dr. Zarestky ($8,639/month base salary) will be responsible for planning and conducting the project evaluation.

Other Personnel ($162,142):
Salary ($2,283/month base salary) is requested for a Graduate Research Assistant who will research existing educational materials on plant genetic resources, identify gaps in those offerings, develop content for the learning materials, assist with development and teaching of the online courses, and help supervise undergraduate students. We are requesting 6 months in year 1, 12 months in year 2 and 8 months in year 3 for the GRA,

Salary is requested for a half-time Administrative Professional ($3,654/month base salary; 6 months per year) for each year of the project. This person will supervise learning object development by providing guidance and assistance for video editing, adding voice-overs and closed captioning, and uploading content to YouTube and Pressbooks. This person will also research specific content areas and identify existing content related to PGR utilization. The AdminPro will work closely with Dr. Kinard's team to design and build the NPGS training website.

Salary ($3,903/month base salary, 1 month per year) is requested for Administrative Assistant Kierra Jewell (a State Classified employee), who will establish and maintain a project management website with relevant reference materials, meeting notes, planning documents, and draft versions of the learning materials. She will also be responsible for arranging travel, ordering supplies, and assisting with management of the online courses and dissemination of the project's learning materials.

Undergraduate student hourly workers will be hired at $14/hour for 500 hours/year to assist with crop management in greenhouse and field, demonstration of PGR practices for videos, video editing, and creation of diagrams and illustrations.

All salaries, except the Undergraduate student hourly, are inflated by 3% each year.

Fringe Benefits ($52,658):
Fringe benefits are budgeted at the following proposed fringe rates: Faculty 28.7%, GRA 8.4%, AdminPro 28.7%, State Classified 43.1%, and Student Hourly 1.1%. Fringe will charged at the rate in effect when salary is incurred.

Domestic Travel ($9,500):
Travel to professional meetings. Each of the CSU co-PI's (Byrne, Munoz-Amatriain, and Zarestky) and the graduate student will be funded to attend and participate in a relevant professional society meeting in Years 2 or 3 to disseminate the project's products and results. A total of four trips (2 trips in year 3 and 2 trips in year 3 at $2,000 each) are budgeted. Meeting locations are unknown at this time. The estimated per trip cost includes reasonable estimates for airfare, lodging, per diem, registration and ground transportation for a 3-night trip.

Travel to a Project Directors meeting ($1,500):
Funds are requested for Dr. Byrne to travel to a Project Directors meeting in year 1 only as required by the Request for Applications. A 3-day trip to Washington, DC is used for budgeting purposes. Airfare and ground transportation are estimated at $700, hotel for 3 nights at $600, and per diem at $200.

Other Direct Costs:

Materials ($7,500):
$2,000 per year is requested for supplies, including greenhouse and field supplies (pots, soil media, stakes, flags, drip irrigation, harvest bags, small hand tools) and computer supplies (portable hard drives, jump drives). The field and greenhouse supplies are needed to grow plants that will be featured in videos and photos for the learning materials. The portable hard drives and jump drives will be used to store and transfer large files between labs. In addition, Computer software purchases/licenses of $500 per year is budgeted for purchases related to implementation of the project, for example for video editing or graphic design/illustration.

Consultant Services ($48,000):
Consultant Dr. Deana Namuth-Covert will be funded for 200 hours at $80/hour for each year of the project. She will provide information and guidance on course design, and development and assessment of learning objects and online lessons.

Subawards ($231,086):
A subaward of $139,692 to Iowa State University is included in this project.

Dr. Suza will be involved in development of instructional materials and making the materials available through the PBEA website.

A second subaward of $91,394 to USDA-ARS is also included.

The contribution by USDA Co-PIs will focus on Objectives 1, 2, 3, and 5. Dr. Volk and Dr. Gardner will help prioritize the training resources that will be developed (Objective 1) and they will develop training module content relating to plant genetic resources conservation and use with the assistance of temporary student employees at the Fort Collins, CO and Ames, IA locations. Content will include ebook chapters, videos, websites, and images (Objective 2). USDA Co-PI Dr. Kinard will make the training resources freely available through a new website interface developed by the National Germplasm Resources Laboratory (Objective 3). All three Co-PIs will disseminate information about the training resources at conferences, meetings, presentations, and journal articles (Objective 5).

Equipment/Facility Use Fees ($3,000)
We request funding for space rental and crop management expenses at the CSU research farm (ARDEC) and the greenhouses at Plant Growth Facilities. For each facility we request $500 per year for Years 1 to 3. This space will be used to grow and video-record PGR accessions relevant to the course modules and other learning materials.

Video Recording and Editing ($12,500)
We request $5,000 each in Years 1 and 2 and $2,500 in Year 3 for video recording and initial editing services related to the development of learning materials for the three 1-credit modules and stand-alone learning objects. The video will be produced by a Digital Media Specialist in CSU's College of Agricultural Sciences. The budget is based on the established rate of $100/hr and 50 hours of estimated time per year to produce the videos.

Indirect Costs ($144,210):
Indirect costs are budgeted at CSU's federally negotiated rate for Other Sponsored Activity of 34% of Modified Total Direct Costs (MTDC). In this budget subaward budgets more than $25,000 are exempt from the base. MTDC = $605,233 - $181,086 = $424,147. Indirect cost = $424,147 * 34% = $144,210. The total indirect costs, including subaward indirect, budgeted for the project ($188,010) are less than the USDA NIFA limit of 30% of total federal funds.

Total Direct and Indirect Costs ($749,443)